HAPTIC ACTUATOR INCLUDING SLIDABLY COUPLED MASSES AND RELATED METHODS

TECHNICAL FIELD

[0001] The present disclosure relates to the field of electronics, and, more particularly, to the field of haptics.

BACKGROUND

[0002] Haptic technology is becoming a more popular way of conveying information to a user. Haptic technology, which may simply be referred to as haptics, is a tactile feedback based technology that stimulates a user's sense of touch by imparting relative amounts of force to the user.

[0003] A haptic device or haptic actuator is an example of a device that provides the tactile feedback to the user. In particular, the haptic device or actuator may apply relative amounts of force to a user through actuation of a mass that is part of the haptic device. Through various forms of tactile feedback, for example, generated relatively long and short bursts of force or vibrations, information may be conveyed to the user.

SUMMARY

[0004] A haptic actuator may include a housing having a top and a bottom, and first and second coils carried by the top and bottom, respectively, of the housing. The haptic actuator may also include a field member carried by the housing. The field member may include at least one permanent magnet between the first and second coils, first and second ends, and a first mass between the first end and the at least one permanent magnet, and a second mass between the second end and the at least one permanent magnet. The haptic actuator may also include a first shaft may slidably couple the first mass to the housing, and a second shaft may slidably couple the second mass to the housing. The haptic actuator may also include a first set of biasing members between the first end of the field member and the housing and a second set of biasing members between the second end of the field member and the housing. Accordingly, the haptic actuator may provide increased force haptic feedback and occupy less space in an electronic device, for example, be relatively smaller in terms of height.

[0005] The first and second coils may be first and second loop shaped coils, for example. The field member may include a third mass between the first and second masses and having a reduced width relative to the first and second masses. The at least one permanent magnet may be a plurality of permanent magnets carried on each side of the third mass, for example.

[0006] The haptic actuator may also include first and second mechanical bearings carried by the first and second masses and slidably receiving the first and second shafts. The housing may include at least one sidewall between the top and bottom and that may include non-ferritic material, for example. The top and bottom may each include ferritic material.

[0007] The haptic actuator may also include a mechanical stiffener carried by one of the top and bottom of the housing. The first and second sets of biasing members may include first and second sets of springs, for example.

[0008] The first and second ends of the field member may include first and second sets of protrusions coupled to the first and second sets of biasing members, respectively. Each of the first and second sets of biasing members may each have an equal number thereof between a respective one of the first and second ends and adjacent portions of the housing, for example.

[0009] An electronic device aspect is directed to electronic device that may include a device housing and wireless communications circuitry carried by the device housing. The electronic device may also include a haptic actuator carried by the device housing and that may include an actuator housing having a top and a bottom, first and second coils carried by the top and bottom, respectively, of the actuator housing, and a field member carried by the actuator housing. The field member may include at least one permanent magnet between the first and second coils, first and second ends, and a first mass between the first end and the at least one permanent magnet, and a second mass between the second end and the at least one permanent magnet. The haptic actuator may also include a first shaft slidably coupling the first mass to the actuator housing, a second shaft slidably coupling the second mass to the actuator housing, a first set of biasing members between the first end of the field member and the actuator housing, and a second set of biasing members between the second end of the field member and the actuator housing. A controller may be to the wireless communications circuitry and the haptic actuator capable of performing at least one wireless communication function and selectively operating the haptic actuator.

[0010] A method aspect is directed to a method of making a haptic actuator. The method may include positioning first and second coils to be carried by a top and a bottom, respectively, of a housing and positioning a field member to be carried by the housing. The field member includes at least one permanent magnet between the first and second coils, first and second ends, and a first mass between the first end and the at least one permanent magnet, and a second mass between the second end and the at least one permanent magnet. The method may also include slidably coupling the first mass to the housing using a first shaft and slidably coupling the second mass to the housing using a second shaft. The method may further include positioning a first set of biasing members between the first end of the field member and the housing and positioning a second set of biasing members between the second end of the field member and the housing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. **1** is a perspective view of an electronic device including a haptic actuator according to an embodiment of the present invention.

[0012] FIG. **2** is a schematic block diagram of the electronic device of FIG. **1**.

[0013] FIG. **3** is a perspective view of a portion of the haptic actuator of FIG. **1**.

[0014] FIG. **4** is an exploded perspective view of the haptic actuator of FIG. **3**.

[0015] FIG. **5** is an electromagnetic simulation diagram of the haptic actuator of FIG. **3**.

[0016] FIG. **6***a* is a perspective view of a portion of a haptic actuator according to another embodiment.

[0017] FIG. **6***b* is cross-sectional view of the portion of the haptic actuator of FIG. **6***a* taken along line **6-1**.

[0018] FIG. **7***a* is a perspective view of a portion of a haptic actuator according to another embodiment.